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Factors to Curb Tax Evasion: Evidence from the TAXSIM Agent-Based Simulation Model

LÁSZLÓ GULYÁS – TAMÁS MÁHR –

ISTVÁN JÁNOS TÓTH

INSTITUTE OF ECONOMICS, CENTRE FOR ECONOMIC AND REGIONAL STUDIES,
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Authors:

László Gulyás
director of research
AITIA International, Inc.
e-mail: lgulyas@aitia.ai

Tamás Máhr
project manager
AITIA International, Inc.
e-mail: tmahr@aitia.ai

István János Tóth
senior research fellow
Institute of Economics - Centre for Economic and Regional Studies
Hungarian Academy of Sciences
e-mail: toth.istvanjanos@krtk.mta.hu

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Factors to Curb Tax Evasion: Evidence from the TAXSIM Agent-Based Simulation Model

László Gulyás – Tamás Máhr – István János Tóth

Abstract

Agent based models are proposed as an adequate tool for analysing tax payer decisions and, thereby, the consequences of such decisions as they manifest themselves at the macro level. TAXSIM models the conduct of agents of three types, i.e. employers, employees and the government, in an economy of a single sector. Using this model, we examine the conduct of each individual agent and the impact of their decisions on the size of tax evasion and aggregated tax revenues. The main objective is the analysis of the relations between the government and tax payers, as well as the identification of how this relationship affects tax evasion.

In this paper, the operation of several factors affecting the incidence of non-registered employment is studied with the help of an improved version of the TAXSIM agent-based simulation model. We analyse the effects of unemployment experience, the quality of government services and the audit strategy of the tax authority on totally hidden, mixed (hidden and legal) and totally legal payments. We start by a brief overview of the TAXSIM model and introduce the novel components in detail. This is followed by a thorough analysis of a vast series of computational experiments, analysing the behavior of the base model, as well as the effect of the newly introduced components (i.e., unemployment experience, adaptive audit strategy, etc.) and their various parameters.

Our computational results suggest that the government can use effective tools to improve tax morale and curb tax evasion. Beyond improving the frequency and precision of tax audits the implementation of an adaptive tax audit strategy, the reduction of the exposure to unemployment or, on the motivation side, the improvement of the quality of government services can also be effective.

Revised version of the paper presented in Münster at the Shadow 2013 Conference (http://www.wiwi.uni-muenster.de/shadow2013/)

Keywords: tax evasion, quality of governmnet, unemployment, social network, agent based model

JEL: H26, C63, E24

Az adócsalást csökkentő tényezők: eredmények a TAXSIM ágens alapú szimulációs modellből

Gulyás László – Máhr Tamás – Tóth István János

Összefoglaló

Agens alapú modellek megfelelő eszközként javasolhatók az adófizetői döntések elemzésére és ezáltal annak elemzésére is, hogy milyen következményekkel járnak ezek a döntések makro szinten. TAXSIM-modell három szereplő – a munkáltató, a munkavállaló és a kormányzat – magatartását veszi figyelembe egy egyszektoros gazdaságban. A modell segítségével az egyes szereplők magatartásának hatását vizsgáljuk az adócsalás elterjedtségére és az összesített adóbevételekre. Az elemzés fő célja a kormányat és az adófizetők közötti kapcsolat vizsgálata, és az, hogy e kapcsolat hogyan hat az adócsalás elterjedtségére.

A tanulmányban több különböző tényezőnek a nem regisztrált foglalkoztatásra gyakorolt hatását vizsgáljuk az általunk korábban létrehozott TAXSIM ágens alapú szimulációs modell továbbfejlesztett változatával. Elemezzük a munkanélküliségi tapasztalatnak, a kormányzati szolgáltatások minőségének, az adóhatóság ellenőrzési stratégiájának a hatását a teljesen rejtett, vegyes (rejtett és legális) és teljesen legális kifizetések gyakoriságára. A tanulmány első részében a TAXSIM-modell rövid áttekintését adjuk, majd részletesen ismertetjük a modell új összetevőit. Ezt követi több számítási, futtatási kísérlet alapos elemzése, amelyben először az alapmodell működését vizsgáljuk, majd ennek újonnan bevezetett komponenseit (pl. a munkanélküliségi tapasztalat, az adaptív ellenőrzési stratégia stb) különböző paraméterek mellett.

A számítási eredmények azt sugallják, hogy a kormány hatékony eszközöket használhat az adózási morál javítására és az adócsalás megfékezésére. Azon túl, hogy gyakoribbá teszi az adózók ellenőrzését és az adóellenőrzések pontosságát, egy adaptív adóellenőrzési stratégia bevezetése, a munkanélküliség gazdaságon belüli szerepének csökkentése, vagy a kormányzati szolgáltatások minőségének javítása egyaránt hatékony stratégiaként kínálkozik.

Tárgyszavak: adócsalás, kormányzat minősége, munkanélküliség, társadalmi kapcsolathálók, ágens alapú modell

JEL kódok: H26, C63, E24

Introduction

The microeconomic models (Allingham–Sandmo, 1972; Srinivasan, 1973; Alm, 1988; Cowell, 1985; Sandmo, 1981) describe taxpayer conduct with the help of one or several utility functions. In such models, depending on the standpoint of the particular model, either the tax payer or the government tries to maximise their utility. The weakness of approaches of this kind is the utility function itself, which, let alone that it defines only a single and unchangeable strategy for every agent (e.g. tax payers), it also degrades society into the aggregate of stand-alone agents.

In contrast, the agent-based models implement all agents, with possibly varying and evolving strategies, as well as their connections and influences on each other. Thus, they offer to be an adequate tool for analysing tax payer decisions and, thereby, the consequences of such decisions as they manifest themselves at the macro level. The initial agent-based tax evasion models expanded the use of utility functions through the application of inhomogeneous agents, each of which optimizes its own (and, perhaps the social) utility by one of the several possible utility functions (Davis–Hecht–Perkins, 2003; Mittone–Patelli, 2000). Subsequent models convert the coefficients derived from the utility function into agents, turning into complex behaviour, for example, tax audits (Balsa–Antunes–Respício–Coelho, 2006). In addition several developments also emerge like, for example, the tax payer social network, as an important parameter of the model (Bloomquist, 2006). A further step ahead was made (Hokamp–Pickhardt, 2010), when the authors analysed, using four agent types (maximizing, imitating, ethical and random), the impact of government policies on tax payer behaviour. In addition to the models based on standard microeconomic assumptions the analyses that constitute models capable of reproducing the results of agent-based models can be taken as an expansion of such approaches. Such is the use of the standard model of statistical mechanics (Pickhardt – Seibold, 2011). Another relevant path is the use of a research strategy, which compares the results of the model assuming social preferences with those derived from the agent-based model based on assuming the heterogeneous conduct and heuristic decisions of agents (Méder–Simonovits–Vincze, 2012).

The approach we have used in TAXSIM models the conduct of agents of three types, i.e. employers, employees and the government, in an economy in which there is a single sector. We examine, using various parameter settings, the conduct of each agent and the impact of their decisions on the size of tax evasion and aggregated tax revenues (Szabó et al, 2008; Szabó et al. 2010; Szabó et al., 2011). The main objective of the research has been the analysis of the relations between the government and tax payers, as well as the identification of how this relationship affects tax evasion.

In this paper we expand the TAXSIM model through resolving several limiting assumptions having been used earlier and examine the impact of the same on tax paying behaviour and aggregated tax revenues. Furthermore we also analyse the possible effects of several governmental initiatives.

First, the government may enhance the efficiency of tax audits. In particular, the tax authority follows an adaptive strategy of tax audits (Section 4). In the second case, , the government improves the level of services offered to employers and employees (Section 6). Third, the effects of the implementation and increase of the minimum wage, as a governmental measure, is also analysed on tax payment behavior (Section 5).

In addition to the relationship between the government and tax payers, we also examine how tax payment behaviour depends on the structure of the social networks of employees' and employers' (Section 7). Finally, we analyse how employees' earlier unemployment experience changes the amount of tax evasion (Section 8).

In Section 2 we describe the respective elements of the TAXSIM model in a greater detail. Section 3 offers an analysis about the general conduct of the model as a function of various parameter settings. These analyses will help us to familiarize with the behaviour of the model in the various parameter ranges, so that such parameter ranges can be brought into correlation with the observed behaviours of the economic and political model and we can select the settings using which to continue our experiments.

1. THE TAX EVASION MODEL

The TAXSIM model is concerned with the operations of a single market sector, where there are four kinds of agents involved: employee, employer, (tax) authority and government. The economic well-being of employees depend on their net wages, while that of the employers' is a function of the market demand and the level of gross wages they are forced to pay. The rate of tax evasion is an agreement between an employer and an employee that is made when the employee occupies a new job. As the agreed employment type determines the income of the employee and the (producing) costs of the employer, both participating agents have a motivation to evade.

The government and the tax authority have service providing and regulatory roles, respectively. Since the market demand is modeled as an exogenous component and employers and employees are assumed to be homogeneous in technological and productive ability, competitiveness is determined by the agents' approach to taxes.

In this model tax evasion is a technique to reduce costs (and to raise wages). Therefore a more refined measure of level of the evasion fits better our purposes than the classical binary

or ternary choice (e.g., complier/evader, or complier/evader/skeptic). Thus, we used the five types of income (those found empirically most common in Hungary – both legal and non-registered ones) to create employment types. An employment type is the combination of reported wage, fringe benefits, ad hoc engagement agreement, unreported wage and payment in kind (see Table 1 for the 23 possibilities). Note that fringe benefits have no meaning without a reported wage, so all combinations that include the first without the other (8 pieces) are omitted. Furthermore, the employment types are grouped so that when there's no reported wage it is termed non-registered (or hidden) and it is called legal when there's only reported wage and fringe benefits. The remaining combinations belong to the group of mixed employment.

The agents have no perfect information about the policies of the government and of the accuracy of the tax authority. These they learn from previous experiences and via interactions within their social network. Thus, in addition to the agents, the last major component of the model is the social network of both the employees and the firms. The employees and employers use their knowledge during the so called negotiation process that takes place when an employee occupies a new job. During the negotiation procedure both the employer's and the employee's expectations depend on their respective satisfaction with the government and on the estimated costs and benefits of evasion. Previous interactions with the authority agent (audits) and information derived from the social network determine cost and benefit estimations. It is also assumed that all agents utilize some services provided by the government (e.g. a company wants to register a trademark, or a person wants to get a passport). These interactions (the experienced effectiveness, corruption, etc.) determine the contentment of the agent.

Table 1.1

The 23 employment types

No.	Reported wage	Fringe benefits	Invoiced payments	Unreported wage (Concealed cash payments)	Payment in kind	Type
1	●					Legal
2	●	●				Legal
3	●		●			Mixed
4	●			●		Mixed
5	●				●	Mixed
6	●	●	●			Mixed
7	●	●		●		Mixed
8	●	●			●	Mixed
9	●		●	●		Mixed
10	●		●		●	Mixed
11	●			●	●	Mixed
12	●	●	●	●		Mixed
13	●	●	●		●	Mixed
14	●	●		●	●	Mixed
15	●		●	●	●	Mixed
16	●	●	●	●	●	Mixed
17			●			Hidden
18			●	●		Hidden
19			●		●	Hidden
20			●	●	●	Hidden
21				●		Hidden
22				●	●	Hidden
23					●	Hidden

The model of the market sector is kept as simple as possible. Companies (employers) producing the cheapest goods sell first. When demand is less than the actual productivity, companies producing most expensive goods will meet losses that may force them towards evasion. A similar force is faced by the employees: after a period of unemployment (the length depending on the agent's reserves that in turn, depend on the length of previous employment) an employee decreases its expectations and will eventually accept any job offer.

The novelty of TAXSIM is that taxpayer compliance is strongly affected by the environment of the agent. An agent who decides to evade tax on a certain level has to find a job offer that meets her preferences: if she is unable to find one, she will make a compromise and accept an available offer that is closest to her preference. The other novelty is that agents accept the need for taxes in TAXSIM. That is, taxpayers experience taxes as the price of services they use (e.g. courts, education, etc.).

In the following, we detail the properties and behavior of the individual model components.

EMPLOYERS

The main attributes of an employer are: list of employees, compliance level, level of satisfaction, current job offer (if any), budget, the amount of produced goods per month, estimated accuracy of the authorities, estimated frequency of audits. Initially, all employers have the same amount of money, an initial job offer, and no employees hired. Employer agents start to operate by hiring employees and selling products. Costs are the wages, while income is the price of the sold products (the price of a single product depends on the employer's average wage cost and the profit margin, the latter being a model parameter). Employers operate until becoming bankrupt.

Employers have an implicit strategy to produce as cheap as possible, which is realized by making tax evasion deals with employees. The key this is the negotiation process, in which employers make job offers. A job offer is a pair of a wage and an employment type. The overall production cost per employee (i.e., the gross salary) is assumed to be fixed, thus the agent's decision is about the tax evasion rate. The agents try to optimize the following function:

$$\boldsymbol{V}(B, a_2) = B(a_1 - a_2) - pqfB(a_1 - a_2) \rightarrow \max(a_2)\,. \qquad (\mathbf{1})$$

Where B is the gross salary (constant within a simulation), a1 is the tax rate (constant within a simulation), a2 is the actual tax rate paid, p is the chance of audit, q is the chance of being caught during an audit in case of evasion (accuracy of the authority) and f is the fine

rate (constant within a simulation). The agent learns the value of p and q. The following formula is equivalent to (1):

$$\boldsymbol{V}(B, a_2) = B(a_1 - a_2)\ (1 - pqf) \rightarrow \max(a_2)\ . \qquad (\mathbf{2})$$

Equation (2) implies that when $pqf = 1$ then the value of a_2 is indifferent; when $pqf > 1$ evasion produces deficit; while when $pqf < 1$ evasion produces profit. Evaluating (2) is the basic decision procedure when an employer offers a new job. Altering the offer means that the employer shifts her current compliance level (that is between 0 and the tax rate) one step towards the profitable direction (for example: when $pqf < 1$ and the compliance level is mapped to employment type 7, then the employer will offer a new job with type 8 – see Table 1 for employment types).

However, the above function is constrained by the employer's contentment level, derived from governmental interactions that determine the minimum level of compliance (that can be zero). Moreover, the produced new offer needs to match the employee's preferences. Feedback from employees modifies the employer's strategy when no one accepts the offer for a period of time.

EMPLOYEES

The main attributes of an employee are: employer (if any), employment type, savings, and the level of satisfaction. TAXSIM employees attempt to get a job of their preferences, or any job possible if they are unemployed for a given amount of time. Employees try to maximize their income by avoiding taxes, counting in the potential drawbacks of evasion (e.g. lower expected pension, higher medical costs[ii], etc.). Note that a greater take-home wage doesn't necessarily imply a greater expected income automatically due to additional estimated costs. Expected income is calculated by the following function:

$$\boldsymbol{v}(N, {}_1, {}_2) = N - p_1 N_1 f - p_2 k\ . \qquad (\mathbf{3})$$

Where N is the take-home wage, ${}_1$ is the evaded tax percent, ${}_2$ is the evaded medical insurance (in percent), p_1 is the chance of being caught, p_2 is the chance of illness, f is the fine rate, and k is the medical cost. The agent learns the value of p_1 and p_2. When an employee looks for a job she will evaluate more than one offers using equation (3). If all of the offers are too non-registered (compared to the agent's minimum level of compliance) and the employee has savings (practically, she has not been unemployed for a long period) then she won't

accept any of the offers but keep searching. She will accept the best offer otherwise. (Unemployed agents do not pay any taxes.)

An employee (or an employer) evaluates equation (2) (or (3)) only when a decision is to be made: e.g., when looking for a new job (or wants to hire a new employee). That means agents don't change their compliance level periodically. Employers apply no radical changes on their compliance as they alter their offers by shifting the current compliance level (that is between 0 and the tax rate) one step towards the profitable direction.

Employees live forever: there is no ageing or any fluctuation in the population of the employees. The financial status of the employee has no effect on her work abilities, but it shortens the period she looks for a desirable job.

SOCIAL NETWORKS

TAXSIM includes two distinct social networks of agents transmitting information between neighbors: one connects the employers and the other connects the employees. The model has two options for these networks. They can be modeled by Erdős-Rényi random graphs (Erdős & Rényi, 1959) or by Watts-Strogatz networks (also misnamed as 'small-world networks') (Watts-Strogatz, 1998). Erdős-Rényi graphs have small agent-agent distances (i.e., they are 'small worlds'), an important property of real-world social networks. On the other hand, they don't match other social network attributes (like the clustering coefficient or degree distribution). Watts-Strogatz networks have small peer-to-peer distances as well as local clustering (as in social networks). In TAXSIM an agent's neighborhood doesn't depend on (i.e., correlated with) any of its characteristics (savings, level of compliance, etc).

Both employers and employees transmit information to their neighbors about the experienced accuracy of the authorities and their level of satisfaction. The average of the data received from neighbors affects the estimated accuracy of the authorities and the level of satisfaction respectively.

TAX AUTHORITY

The tax authority audits employees via employers. In each round, some employers are picked for audit depending on the audit frequency parameter. In case of the adaptive audit strategy, some of the employers are picked randomly, while others are selected from the social neighborhood of employers that have previously been audited with non-favorable results. During a particular audit the authority checks the contract of each employee of the employer's.

During the audit, the real employment construct is determined with a certain probability (controlled by the 'accuracy of audit' parameter of the model). If the authority finds mixed or non-registered employment both the employer and the employee is fined, proportionally to the tax evaded, and the employee is forced to quit the non-registered job.

In the first version of the model the tax authority applies a fixed strategy: it does not change its behavior based on the experiences of previous audits. In the new version, a new, adaptive tax audit strategy is also introduced.

GOVERNMENT

In return of taxes paid, agents expect benefits and services from the government agent (e.g. health care for employees, or guaranteed procurement price for EU farmers, etc.). The levels of quality (for employees and for employers, respectively) are parameters of the model. The services are requested in every round by the agents according to probabilities set in parameters. The response is drawn form a distribution determined by the quality of service variable. Agents update their minimum level of compliance by calculating the weighted average of current and past experiences.

2. THE MOST IMPORTANT FACTORS FOR TAX COMPLIANCE

This Section investigates the numerous parameters of the TAXSIM model, in order to analyse their effects on the mixture of the legal, mixed and non-registered employment in the studied economy. To this end, we followed the traditional factor analysis method that means sampling at the corners of a hypercube of the parameter space. We looked for the dimensions (parameters) that produce the highest change between their two levels (i.e., bottom and upper 'corner'). During this sensitivity analysis, we studied the parameters (dimensions) summarized in the table below (table 2.1.). The 2.1. table also specifies the two levels of the studied factors (parameters), i.e., the values of the given dimension at the 'corners'. The parameters not reported in the table are equivalent to the values listed in (Szabó–Gulyás–Tóth, 2009). Therefore, for example, the number of employees was 200 employees and 40 employers, we have studied an economy with almost no unemployment.

Table 2.1

The parameters of the sensitivity analysis

Parameter	Value	Parameter	Value
Tax rate	0,2 – 0,6	Number of employers	40
Minimum tax rate	nincs – 0,2	Probability of the connectedness of the employers' network	0,01 – 0,3
Tax audit probability	0,1 – 0,6	Size of employer neighborhood	0 – 2
Tax audit accuracy	0,1 – 0,6	Number of employees	200
Probability of employees' job search	0,01 – 0,3	Probability of the connectedness of the employees' network	0,01 – 0,3
Number of employers' / employees' groups	0 – 4	Size of employee neighborhood	0 – 2

The results of the study are most clearly shown by the effect on mixed employment. Figure 2.1 has the studied parameters on the horizontal axis, while their effects are on the vertical one. The highest the absolute value of a parameter's effect (i.e., the bar's distance from 0), the stronger its effect is on the output. Positive values show a positive correlation, while negative bars stand for negative effects. According to the figure, the highest effect is produced by the frequency and accuracy of audits. In addition, the connectivity and clustering of the employee and (separately) that of the employer network also has a significant effect. The taxrate, the minimal tax (a model of the minimal wage, see later) and the structure of employer and employee connections have only a secondary effect, via interactions with the above, most important parameters.

The above parameters have similar effects on the number of legal and non-registered employments as well, via changing the number of mixed employments. This is because if the simulated economy moves from mixed employment, it does so gradually, by most contracts changing to legal or non-registered, depending on the parameters.

According to the factor analysis, the most important factors for the composition of labour market in the studied economy are the frequency and accuracy of audits. Therefore, we performed a detailed analysis of the effects of these two parameters. The results are depicted on Figure 2.2. The values of the other parameters and the selection of values for the two studied dimensions (parameters) are summarized on Table 2.2.

Figure 2.1

The effect of parameters on number of mixed contracts

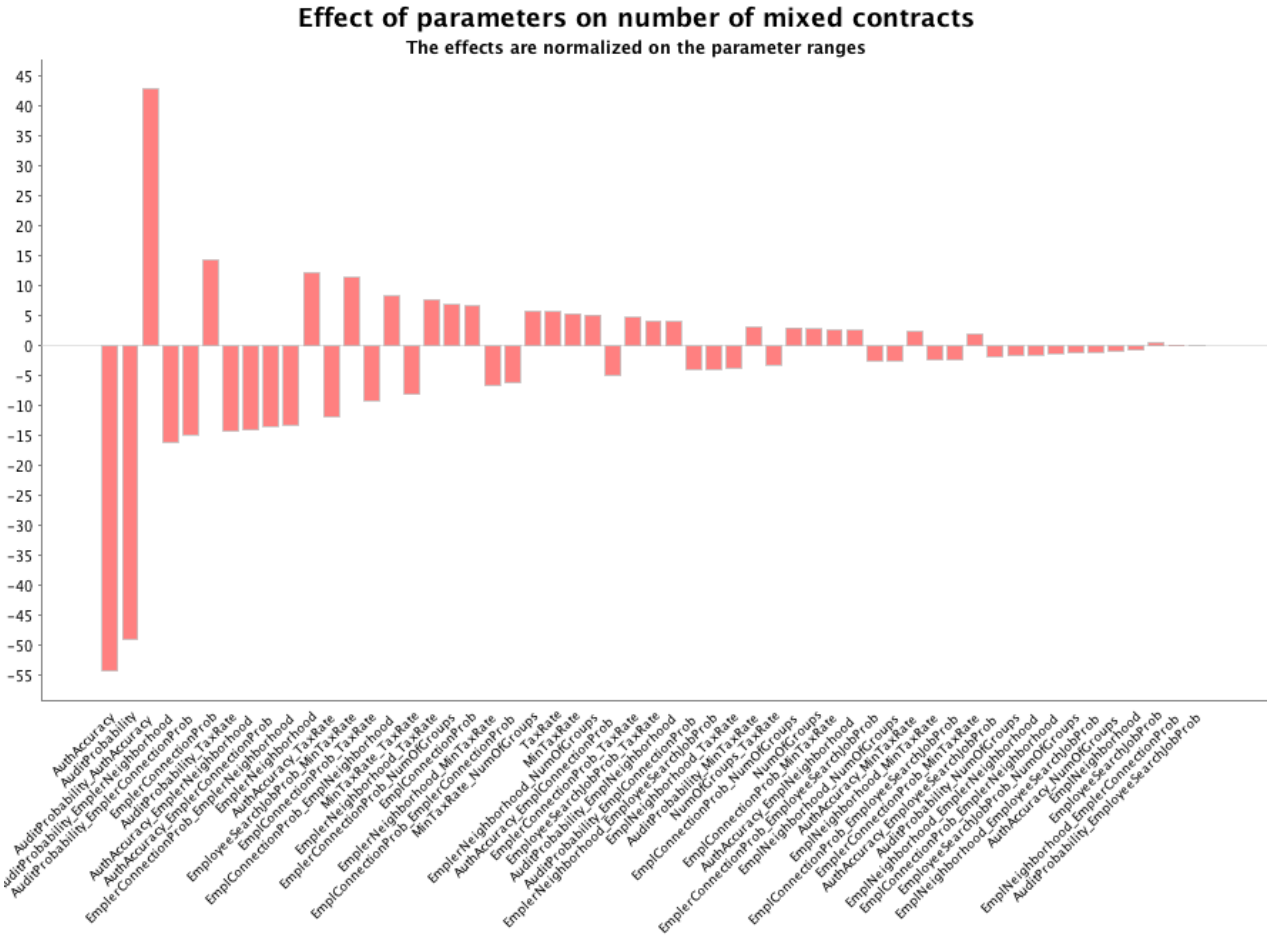


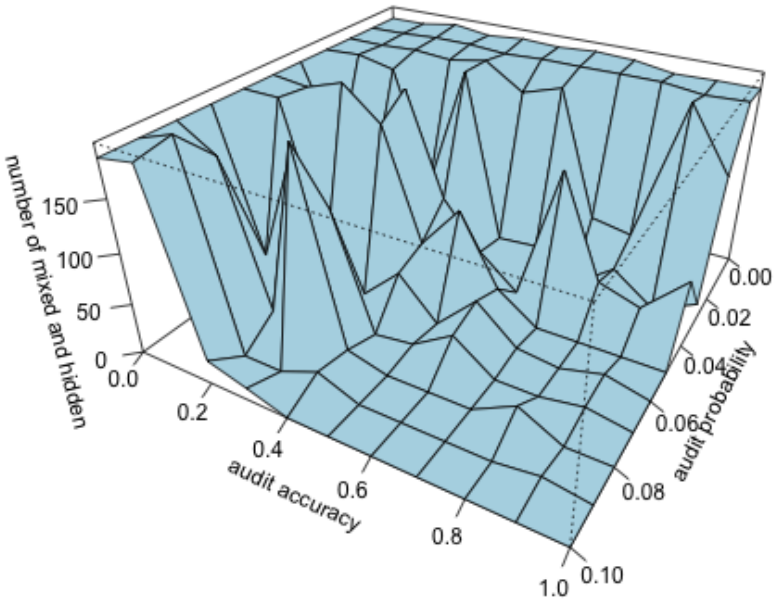
Table 2.2

The parameters of the tax audit experiment

Parameter	Value	Parameter	Value
Tax rate	0,45	Number of employers	40
Minimum tax rate	none	Probability of the connectedness of the employers' network	0,1
Tax audit probability	0 – 0,1	Size of employer neighborhood	0
Tax audit accuracy	0 – 1	Number of employees	200
Probability of employees' job search	0,01	Probability of the connectedness of the employees' network	0,1
Number of employers' / employees' groups	0	Size of employee neighborhood	0

Figure 2.2

The number of mixed and hidden contracts as a function of tax audits



The figure shows quite clearly that, as long as the risk of an audit is negligible (the probability of an audit is small, or the accuracy of the performed audits is minimal), most of the contracts will be hidden. This dark picture lightens up dramatically when moving in either of the two dimensions. At some points we even observe rather steep, „phase transition like" changes. The interaction of the two parameters is also visible: along the diagonal marking their joint increase, the direction of the change is temporarily unstable, showing a turbulent region before reaching complete legality. In this tubulent region, the system's behavior is path-dependent. That is, small early events, often random contingencies may have a significant later effect due to aggregating consequences. This kind of behavior is marked by narrow but sharp, needle-like peaks.

2.1. THE IMPACT OF DIFFERENT ECONOMIC SITUATIONS

Our analysis so far followed the assumptions of (Szabó-Gulyás-Tóth, 2010), working with a sector of the economy in which employment is almost full and labour market competition is slight. As we saw, in a situation like this the legality of employment is basically determined by the efficiency of the tax audit and, in partiular, on the two model parameters that govern it. Their combined effect was illustrated on Figure 2.2.

It is known, however, that there are major interdependences between competition in the labour market and the unemployment accompanying it, on the one hand, and tax evasion on the other. Sociological and economic research based on case studies and field work drew the early attention to the relationship between informal employment, more specifically employment with tax evasion, and unemployment (Pahl, 1987 and Mingione, 1995). Theoretical economic approaches examined the possible impacts of tax evasion on the unemployment, demonstrating that a decline in tax evasion can reduce unemployment (Lisi, 2010). The analysis of a reverse relationship. i.e., the impact of unemployment on tax evasion indicates that higher unemployment results in higher tax evasion (Alm-Yunus, 2009 and Cebula-Feige, 2011).

Motivated by this background, in our next experiments we examine whether and in what ways the behaviour of the TAXSIM system changes when the modeled market sector is facing a different the economic situation. We examine a sector in which the labour market is strongly competitive. For this reason we have chosen parameter settings such that out of the 300 employees available in the labour market on average only 200 employees are actually employed. Table 2.1.1. summarizes the settings that belong to this economy. As the table indicates, in this particular case we have also varied the values of the two parameters that have the major impact and determine the efficiency of tax audit. Figure 2.1.1. below summarizes the result of our analysis.

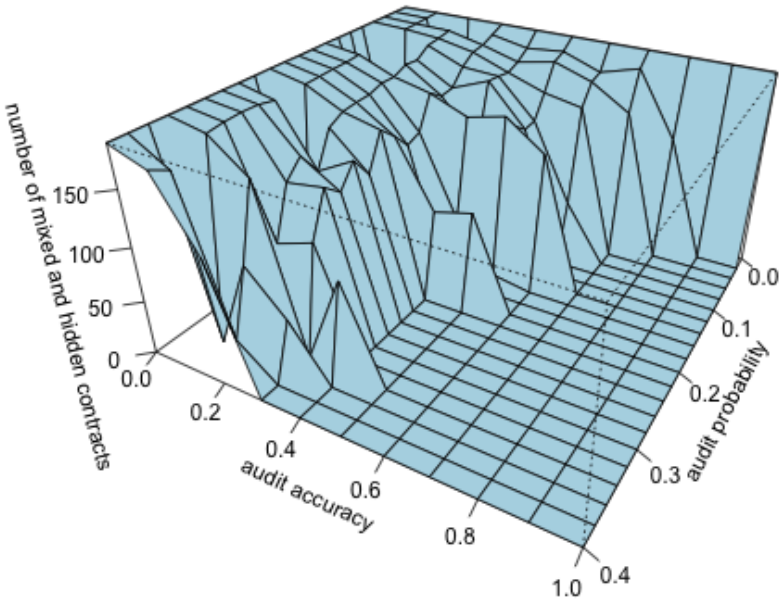
Table 2.1.1

Parameters of a tax audit test performed in a saturated labour market

Parameter	Value	Parameter	Value
Tax rate	0,45	Number of employers	40
Minimum tax rate	none	Probability of the connectedness of the employers' network	0,1
Tax audit probability	0 – 0,1	Size of employer neighborhood	0
Tax audit accuracy	0 – 1	Number of employees	300
Probability of employees' job search	0,01	Probability of the connectedness of the employees' network	0,1
Number of employers' / employees' groups	0	Size of employee neighborhood	0

Figure 2.1.1

Number of mixed and hidden contracts depending on audit assuming 300 employees



As shown in Figure 2.1.1, in an economy generating a significant labour market competition the picture of the economy's legality is similar to the one shown in Figure 2.2. If the values of parameters code a small risk of being caught the number of non-registered employment is high, which declines considerably as the probability increases and may even reach zero in the intervals examined. At the same time it can also be seen that non-registered employment is significant at much higher audit probabilites than before. The nature of the transition between the two legality ranges (regimes) has also changed: the transition phase grows and, accordingly, its steepness reduces. The turbulent zone experienced earlier along the diagonal also seems to settle.

The following Sections will work with this second economic situation, in which there is high competition in the labour market.

2.2. A SEPARATED FACTOR ANALYSIS OF THE TWO MODEL REGIMES

The above analysis showed that the model possesses two rather different regimes of behavior in both labour market situations. Figures 2.2 and 2.1.1. show that an extremely small probability of tax audits and an extreme lack of the efficiency of audit render the economy exceedingly non-registered.

The results at the same time also indicate that a high level of the efficiency of audit can result in curbing the weight of tax evasion and reducing the ratio of mixed and hidden forms of payment even when there is a rather small probability of audit. Reducing the level of tax evasion to a certain level can be implemented at a lower social cost than simply increasing tax audit frequency. This is the reason why it is worthwhile to take a closer look at the effect of increasing tax audit efficiency in the TAXSIM model.

It also means at the same time that it is worthwile to reconsider our factor analysis discussed in the first section. In that analysis, we examined the relative impact of the parameters mapped against all parameter intervals and compared the relative size of the shifts in the outcomes experienced on them. If considering the above, however, it means that the results arrived at when using negligible tax audit risks merge with how the system behaves when "normal", i.e. more standard parameters are selected. In other words the steep increase experienced in the narrow ranges of extremely low tax audit probability and tax audit efficiency appears as a strong impact in the factor analysis.

On the basis of these observations, we repeated the factor analysis, this time separating the extreme regimes of behavior into two separate parameter ranges. Then we proceeded to perform the sensitivity analysis again separately in the top region, when audit probability is low and in the bottom region, when audit probability is high.

Table 2.2.1. below summarizes the parameter settings used in the analysis of cases when audit probability and precision are high, providing the bottom and top values of the dimensions. (It is worthwhile to compare this table with Table 2.1. summarizing the first factor analysis.)

Table 2.2.1

Parameters of the sensitivity analysis performed in the case of high audit probability

Parameter	Value	Parameter	Value
Tax rate	0,45	Number of employers	40
Minimum tax rate	none – 0,2	Probability of the connectedness of the employers' network	0,01 – 0,3
Tax audit probability	0,3 – 0,6	Size of employer neighborhood	0 – 2
Tax audit accuracy	0,4 – 0,8	Number of employees	300
Probability of employees' job search	0,01 – 0,3	Probability of the connectedness of the employees' network	0,01 – 0,3
Number of employers' / employees' groups	0 – 4	Size of employee neighborhood	0 – 2
Quality of government services for employees	0,1 – 0,9	Quality of government services for employers	0,1 – 0,9
Fine rate	0,5	Profit rate	0,1

Figure 2.2.1. ranks parameters, more specifically parameter combinations according to their impacts on the number of legal, whereas figures 2.2.3 and 2.2.4 on the number of mixed and hidden contracts. The horizontal axis of the figures shows the parameters examined and their combinations, whereas the vertical axis indicates their impact on the number of mixed contracts. The higher the deviation from zero of each parameter is, the higher the effect of the parameter is on the outcome. For positive values the direction of the change in the outcome coincides with that of the value of the parameter, whereas it is just the opposite in the case of negative values.

Figure 2.2.1

The effect of parameters on the number of legal contracts

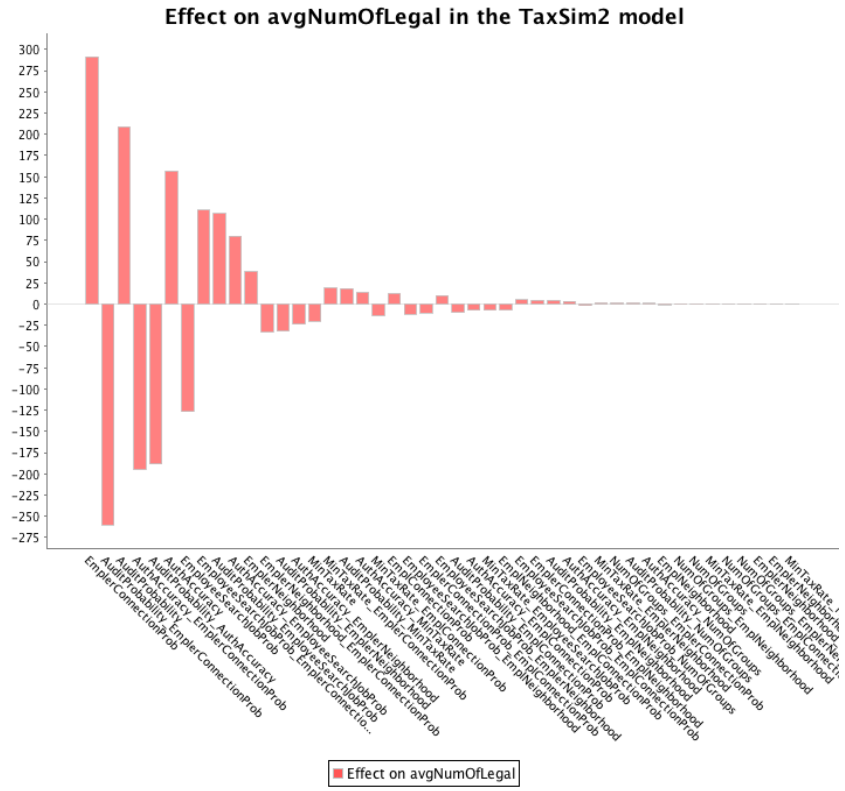


Figure 2.2.3

The effect of parameters on the number of mixed contracts

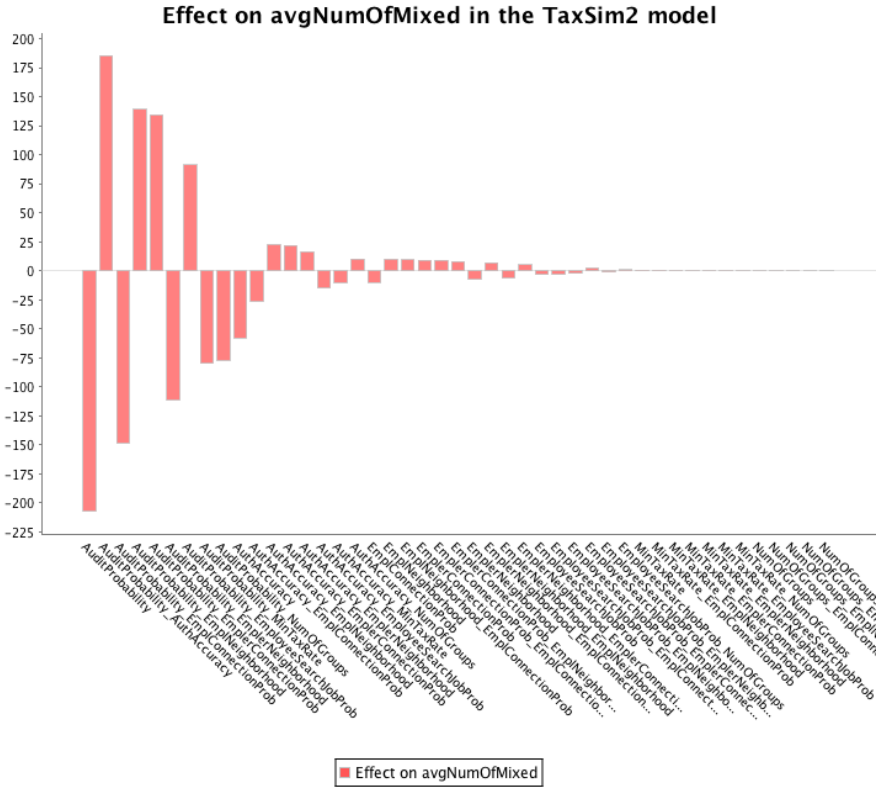
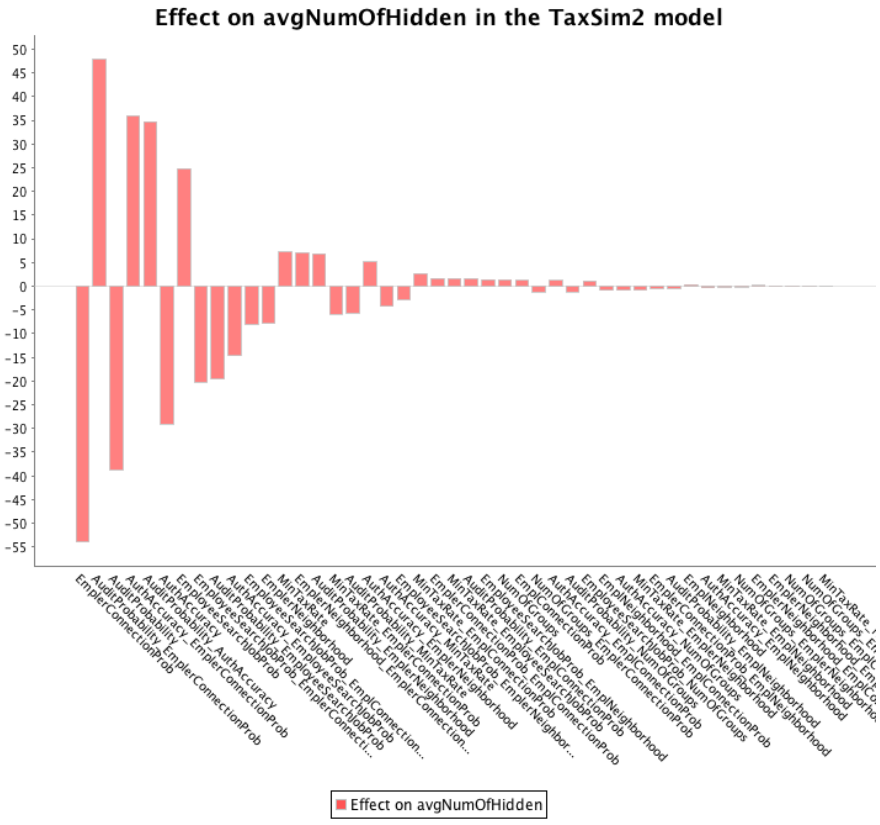


Figure 2.2.4

The effect of parameters on the number of hidden contracts



As evidenced by the figures, the highest effect on the outcome belongs to the probability of tax audits, their precision and the connectedness (density) of the employers' social network as well as the various interactions of these parameters. It is important to note that the connectedness of the employers' information network has a negative impact on tax evasion, i.e. it helps the emergence of legal contracts in the given region. A reason for this is the fact that the bottom value of the parameter that determines the density of the employers' network very likely results in an unconnected network, whereas the top parameter value almost always leads to a connected network. If the network is unconnected, on the other hand, no matter how deterrent the tax audit risk may be if the firms unaudited yet do not learn about it. Accordingly, transferring to a connected network from a low network density whitens the economy due to the propagation of the information. A good indication of this is that the most powerful factor in Figure 2.2.2. is the positive impact of this network density, whereas in Figure 2.2.4. it is also this factor that has the highest, but this time negative impact. In other words non-registered employment contracts can become widespread only when the employers' information network is unconnected. It seems to be in tune with the surface on Figure 2.2.3. (Just as a reminder: here we happen to be in the flat of the "plane" situated near the first corner.)

Table 2.2.5. summarizes the parameter values of our factor analysis performed with low tax audit probability and precision.

Table 2.2.5

Parameters of the sensitivity analysis performed with low audit probability

Parameter	Value	Parameter	Value
Tax rate	0,45	Number of employers	40
Minimum tax rate	none – 0,2	Probability of the connectedness of the employers' network	0,01 – 0,3
Tax audit probability	0 – 0,25	Size of employer neighborhood	0 – 2
Tax audit accuracy	0 – 0,45	Number of employees	300
Probability of employees' job search	0,01 – 0,3	Probability of the connectedness of the employees' network	0,01 – 0,3
Number of employers' / employees' groups	0 – 4	Size of employee neighborhood	0 – 2
Quality of government services for employees	0,1 – 0,9	Quality of government services for employers	0,1 – 0,9
Fine rate	0,5	Profit rate	0,1

Figure 2.2.6

The effect of parameters on the number of legal contracts

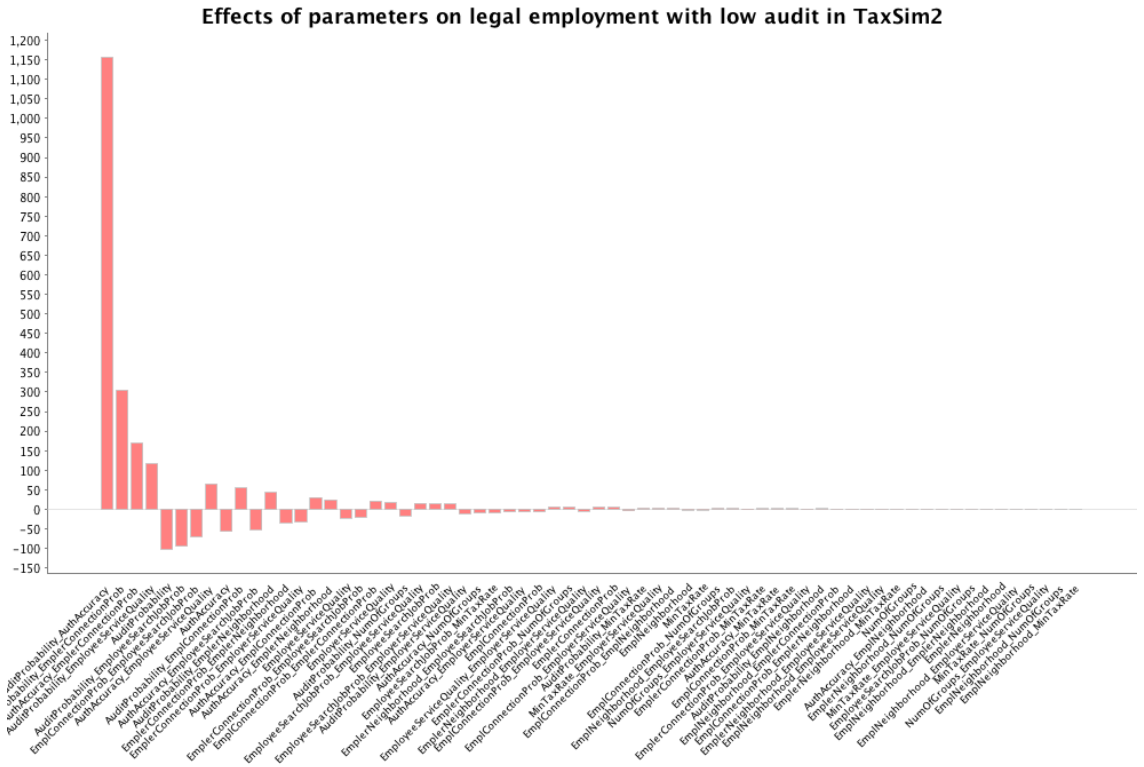


Figure 2.2.6 ranks parameters, more specifically parameter combinations, according to their effect on the number of legal contracts. Figures 2.2.7. and 2.2.8. show the same information for the number of mixed and hidden contracts, respectively. The horizontal axis of the figures shows the parameters analysed, and their combinations, whereas the vertical axis shows their effect on the number of mixed contracts. The higher the deviation from zero of each parameter is, the higher the effect of the parameter is on the outcome. For positive values the direction of the change in the outcome coincides with that of the value of the parameter, whereas it is just the opposite for negative values.

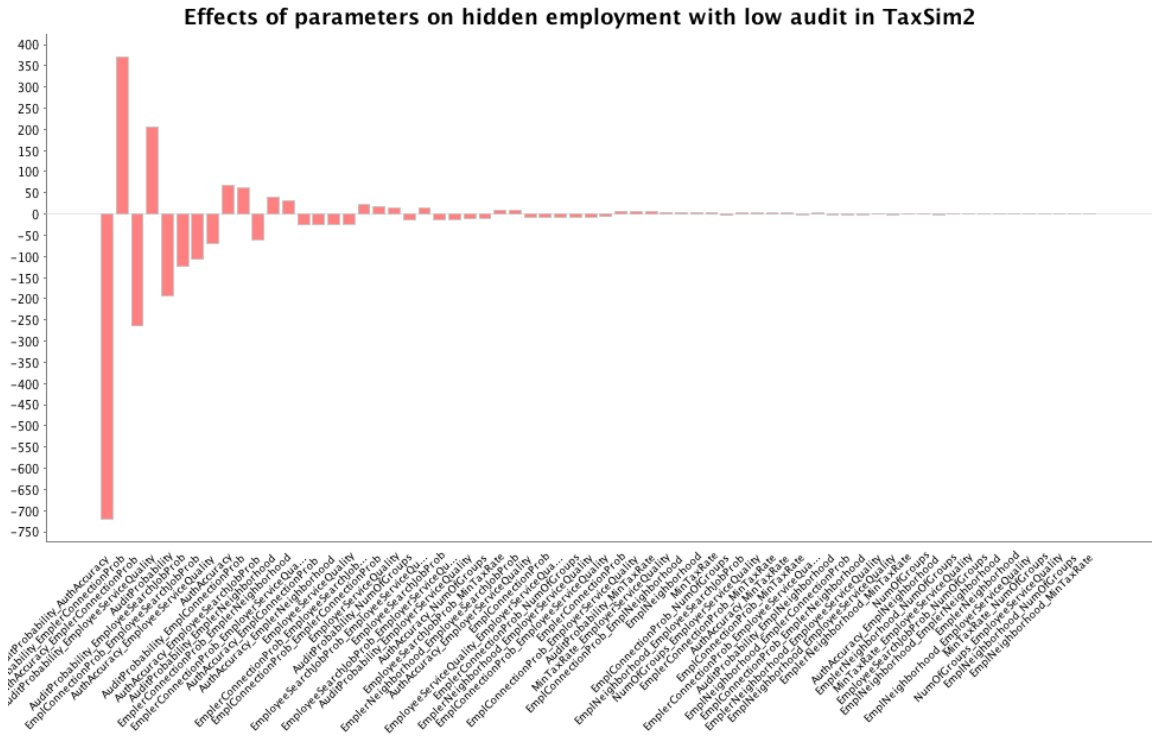
Figure 2.2.7

Effect of the parameters on the number of mixed contracts

Clearly, the figures suggest that, here again, the risk of tax audits has a decisive role. An indication to this is the fact that the two parameters affecting this take the first place in both figures – in various combinations. However, the novelty here is that the EmployerServiceQuality satisfaction appears as a decisive factor in the emergence of hidden economy. In Figure 2.2.8 it shows up on its own in the third place, while it appears in combination with audit precision in the second place and in combination with audit frequency in the fourth place. In the case of legal employment government services extended to employees shows up in combination in the fourth place. Similarly to what we saw earlier, parameters of the employers' information network also play a role in legal and mixed employment.

Figure 2.2.8

Effect of the parameters on the number of hidden contracts



3. THE EFFECT OF ADAPTIVE TAX AUDITS

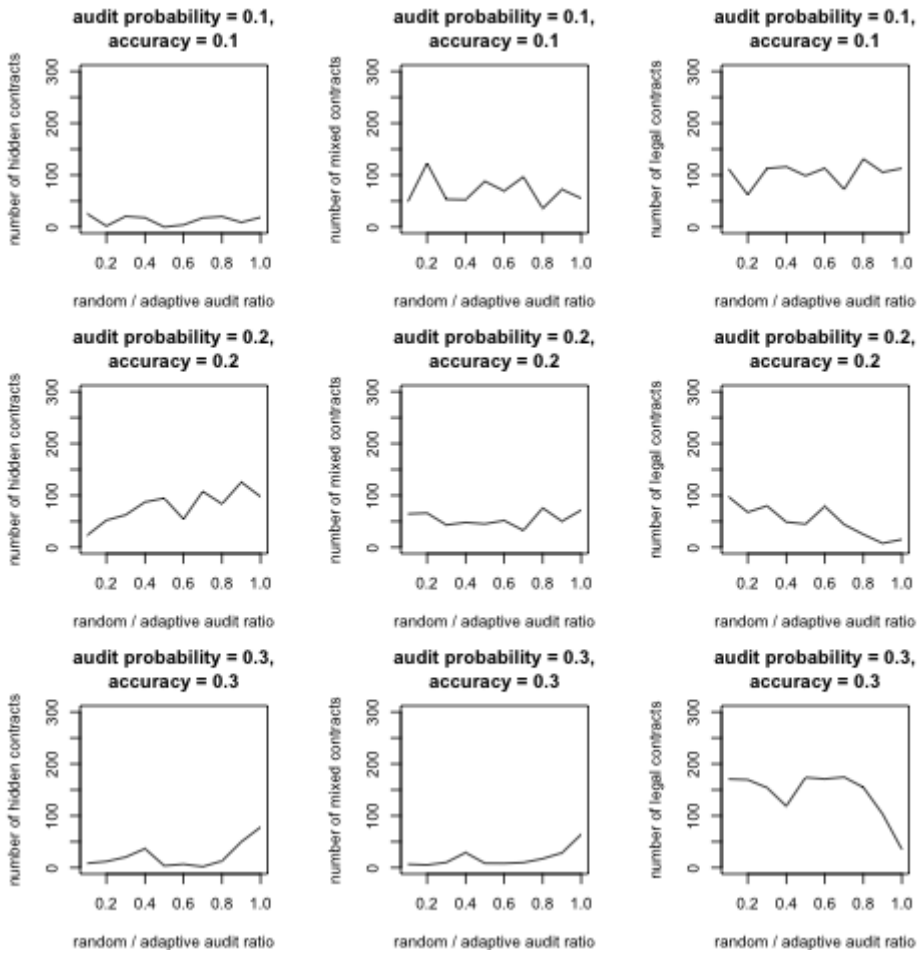
The tax authority can choose several audit strategies in its action against tax evasion. There are empirical and experimental results to suggest that the audit strategies chosen have an important influence on the rate of tax evasion, independently from audit probability. Engel-Hines have shown that retrospective tax audit, which is performed when the tax payer has been found evading tax in the given year, the tax returns for previous years are also audited, can curb tax evasion to a much greater extent than if the size of the fine were doubled (Engel – Hines, 1999). Other research indicated the curbing effect of the audit experience on the one hand (i.e. the tax payer has been audited before), or the audit frequency expected by tax payers (Kleven et al. 2011, Kleven-Schultz, 2012). Tan and Yim highlight the effect of the so called strategic uncertainty on the basis of research results and demonstrate that a high degree of uncertainty of the audits diminished tax evasion to a great extent if compared to situations when tax payers had been informed about the probability of the audit (Tan-Yim, 2011).

Accordingly, it is worthwhile to examine with the TAXSIM model tax payer's behaviour under various audit strategies. In the following, we examine a Tax Authority that, in certain percentage of the cases, does not select the audit target at random, but uses an adaptive selection strategy. The latter means that the choice is made from among the direct network neighbours of the employers having been caught with non-registered (or mixed) labour contracts.

The horizontal axis shows the ratio of the number of employers the tax authority selects randomly and the number of those selected adaptively for audit. At 0 the selection is adaptive, at 1 it is random. The probability and precision of tax audit varies in the various rows. Both are 10% in the first, 20% in the second, and 30% in the third row. The trend that can be observed indicates that the higher the ratio of adaptive selection by the tax authority is, the less is the number of hidden contracts and the more is that of legal contracts.

Figure 3.1

The effect of adaptive tax audits on the number of the various contracts



These results indicate that, instead of the former random selection, it will be worthwhile for the tax authority to select new audit targets from among the acquaintances of employers

having been caught evading tax. In reality the tax authority audits certain firms repeatedly, others randomly. If viewed from these results, it might be worth considering the introduction of some sort of adaptive audit strategy by the tax authority, at the same time it might be also worthwhile to continue to develop the TAXSIM model as well so that it is enabled to better model the prevailing practice of tax audits.

4. THE EFFECT OF MINIMUM WAGE ON TAX EVASION

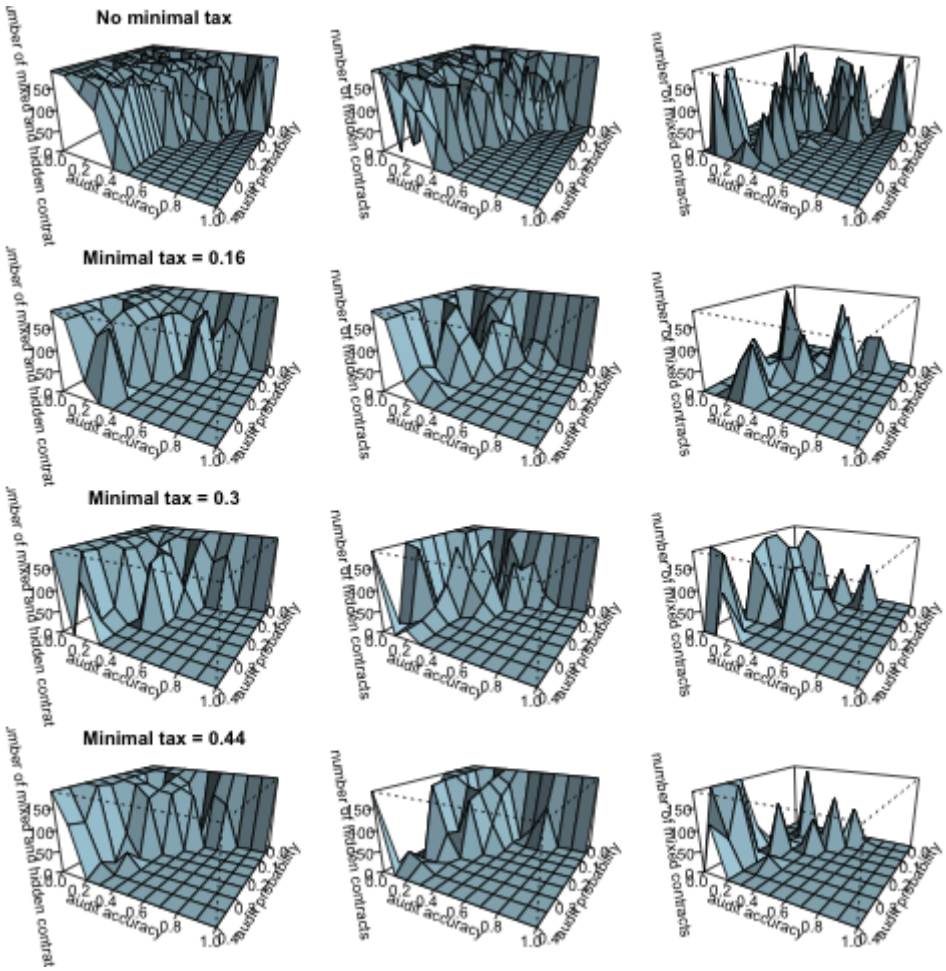
The implementation or increase of the minimum wage can exercise diverse contrasting effects in an economy on the incidence of tax evasion. A special situation emerged in this regard in Hungary in 2001-2002, when the government increased the minimum wage in two steps by a total of 96%. According to assumptions, the minimum wage contributes to the whitening of the economy because the employers that used to pay their employees a mixed compensation package (in a partly admitted and partly unadmitted manner), would either reduce or completely discontinue paying black moneys. This assumption has been supported by Tonin's theoretical model and his analysis carried out on Hungarian data (Tonin, 2011). The findings of other researchers (Köllő-Kertesi, 2004, Halpern et al. 2004, Elek et al. 2012, Benedek et al. 2013) also consider the contrasting effect of raising the minimum wage. Namely, the above effect can be counteracted by the fact that, due to the increased wage charges resulting from the increased minimum wage, employers on the one hand formally dismiss their employees, then they employ them without registration, more specifically increase the share of black compensation within the compensation package.

In the following we introduce the modelled effect of the minimum wage on the legality of employment. As it has been discussed in our previous work (Szabó-Gulyás-Tóth, 2010), minimum wage appears in the form of an increased tax charge in the TAXSIM model in all the employment mixes that contain a reported income (as well). Now we examine the incidence of mixed and black compensation at various minimum wage (tax payment) levels.

In the top row of the following figure the diagram we saw earlier can be seen, which shows the number of mixed and hidden contracts in the function of the probability and precision of the audit. The figure on the left hand side shows the sum of the two categories, whereas the one on the right hand side shows them separately (with hidden contracts in the middle). The minimum size of the tax payable is 16% in the second row, 30% in the third row and 44% in the fourth row. The average tax rate is 45%.

Figure 4.1

The effect of the minimum tax payable on the number of various contract types



According to Figure 4.1. the minimum wage slightly legalizes economy in the particular range of parameters of the TAXSIM model, as the area of the "plane" visible in the first part of the three-dimensional surfaces expands. Even with lower tax audit precision and frequency the size of non-registered employment is smaller and, at the same time, the transfer from non-registered into legal becomes steeper.

Comparing the first and the second rows of the figure one can also observe that the implementation of the minimum wage reduces the ratio of mixed employment compared to hidden employment in the economy that is becoming increasingly legal. So those who are unable to adapt (i.e. become legal), are often forced to withdraw into the hidden economy. At the same time the remaining rows of the figure reveal that this effect reverses as the size of the minimum wage increases. When this happens a slight rearrangement can be observed in non-registered employment from hidden economy towards mixed employment.

It is also worth noticing at the same time that, in the transitory range, mixed employment is conspicuously "pointed" in every figure, which, as we discussed earlier, indicates a strong path dependence.

5. THE EFFECT OF SATISFACTION WITH THE GOVERNMENT

In the classical microeconomic approach of analyis of tax evasion one of the important tools of action against tax evasion is the increased probability of an audit by the tax authority. The higher the probability of audits, ceteris paribus, the higher is the probability of being caught and the lower will be the incidence of tax evasion. In this context, the government can be considered as an agent possessing the power of control and punishment, while businesses and employees, as tax payers can be considered as agents financing governmental expenditures.

Subsequently several researchers pointed out that tax-payers' willingness to pay taxes also depended on how far tax payers recognise the reasonableness of the tax levied by the government (Brennan-Buchanan, 1977; Spicer-Becker, 1980). Further research also drew attention to the role of tax moral and, on the other hand, to the importance of the interactions between the government and the tax payer in determining tax payer's behaviour (Alm et al, 1992; Alm et al. 1993; Frey – Torgler, 2007; Torgler et al., 2010).

Economic psychology research examining the relationship between the government and the tax payer has found that a growing probability of tax audit – contrary to the prediction of the classical microeconomic models – tends to reduce rather than increase the probability of tax payment, as it ruins voluntary tax compliance willingness to a great extent (Kirchler, 2007; Kirchler et al. 2008). According to the same theory, the more the tax payer considers the government to be a cooperating partner and the embodiment of good governance, the more they will be willing to pay tax. International comparative studies also underlined the inter-relationship of governance quality and the relevant tax payer perception and tax payment willingness (Cebula-Feige, 2011).

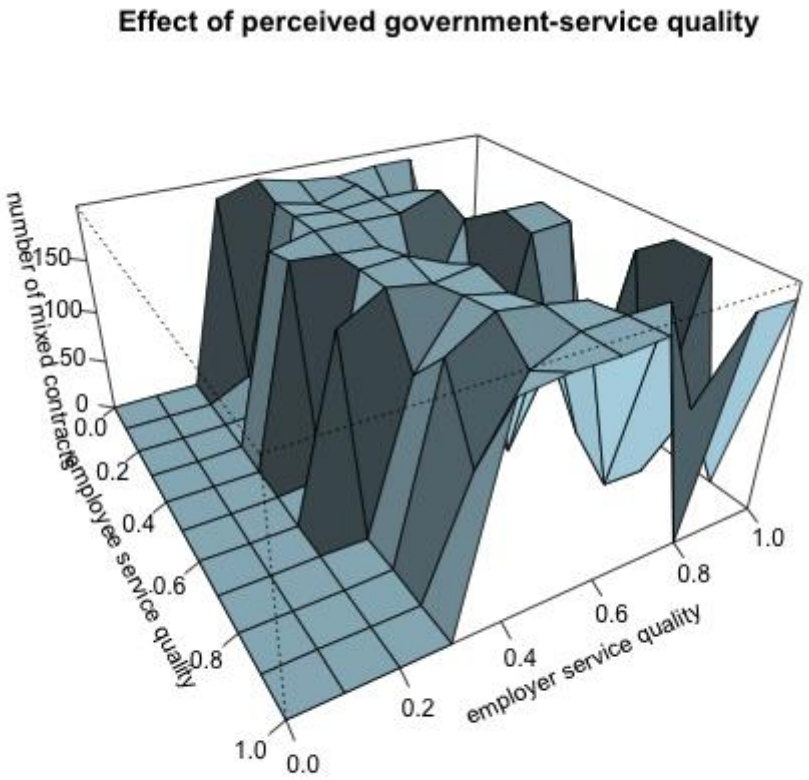
In this Section we examine the effect of satisfaction with the government. In contrast to our earlier paper (Szabó-Gulyás-Tóth, 2010), however, this time we apply the gradual variations in the quality of governmental services to an economy not having reached a balance. (In our earlier work we examined the effect of deteriorating quality after the economy reached a fixed point.) This time we examine, in separate simulation runs, the kind of balance reached by economies as a result of different qualities of governmental services.

The government extends two service types in the TAXSIM model: one for employers and another one for employees. In the figures below we show these two service qualities (and,

respectively, the parameters that regulate them, between 0.0 and 1.0) on the horizontal axis. The vertical axis displays mixed contracts in Figure 5.1, legal contracts in Figure 5.2 and hidden contracts in Figure 5.3.

Figure 5.1

The effect of quality of government services on the number of mixed contracts



The figures clearly indicate that the quality of the services extended to employers by the government dominates the quality of the services offered to employees. It is probably due to the fact that employees are involved in a strong competition with each other in the analysed economy for which reason they are forced to avail of any possibility to work and listen to a lesser extent to their own conviction during the bargaining that determines the tax mix.

In addition, it is also obvious that the better the quality of company services is, the whiter the economy is. When service quality is low employment is overwhelmingly black. It turns into mixed employment in the central range, whereas it is dominated by legal employment in the high quality region. These transitions are modulated by the quality of employee services, but in this case we cannot speak about clear and strong trends. This dimension seems to play a role in the transitional regions, primarily through manifesting path dependence.

Figure 5.2

The effect of quality of government services on the number of legal contracts

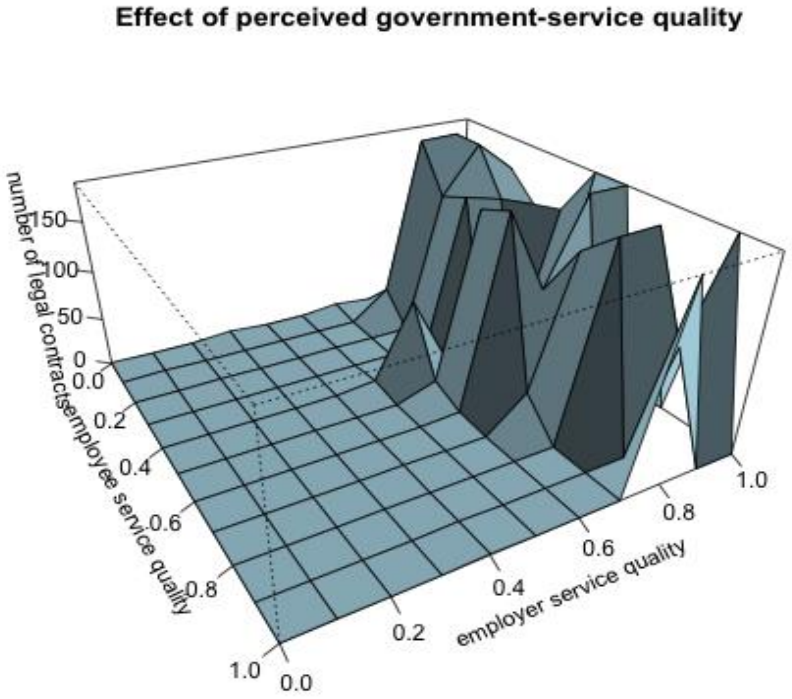
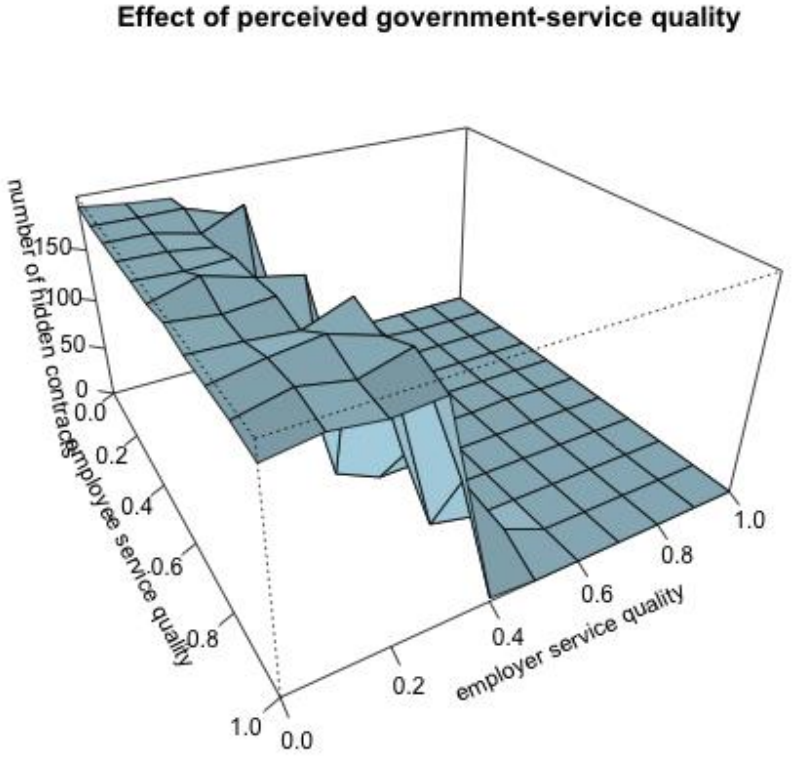


Figure 5.3

The effect of government services on the number of hidden contracts



6. THE EFFECT OF THE STRUCTURE OF SOCIAL NETWORKS

The social networks of tax payers affect the agents' willingness to pay taxes in two ways: on the one hand they learn through these networks about other agents' tax payment behaviour, on the other hand they learn about the probability with which the tax authority audited those who belong to the network. The size and the type of the tax payers' social network, therefore, a priori, can greatly influence the tax payers' willingness to pay tax.

In this Section we examine the effect of the structure of social networks on the composition of employment. Two kinds of social networks are available in the TAXSIM model: one is the information channel of employers, the other is through which employees share their information. In the following, we examine these consecutively. In both cases we shall examine separately the case when we model the network with the Erdős-Rényi version of the random network (Erdős-Rényi, 1959) and the case when the network is generated by the „small world model" of Watts and Strogatz (Watts-Strogatz, 1998).

Before we proceed to presenting our results it is worth recalling the basic features of the networks analysed. The Erdős-Rényi network features N nodes and all edges with the same probability „p". If this probability (which coincides with the expected density of the resulting network) is smaller than ~1/N, the resulting network will probably not be connected. If „p" is larger than ~3/N, the network can practically be considered connected. It is important to note that Erdős-Rényi networks, if connected, possess the so called "small world" property. In other words the average (expected) length of the shortest paths between node pairs scales with log(N).

In comparison, in the Watts-Strogatz model the N nodes are placed in a regular spatial grid so that each node is connected to its neighbors situated at most k (>1) steps from it. In this grid the so called clustering is high, which may be more precisely referred to as transitivity. (Two neighbours of a node are likely to be connected themselves.). It is important, however that the average distance between the node pairs (the average of the shortest paths) is relatively large. The grid, therefore, is not a "small world", as the expected average distance scales with $\sqrt{N}$. Therefore, an important element of the Watts-Strogatz model is the so called "re-wiring" (or, its variation, the "shortcutting") process that adjusts the links of the grid at random, with probability p. Alternatively, we add as a "shortcut", with the probability concerned, the edges not included in the network. In both cases, even at very low "p" values (i.e., very few modified connections) the average distance "collapses" and the network becomes a "small world". In the meantime there is only a small and slow change in transitivity.

Consequently, Watt-Strogatz networks (with most parameter selections) are transitive and "small worlds" at the same time. In addition to that they provide an excellent tool for analysing the effect of "small worldness" (i.e., the expected length of the shortest paths between node pairs) on the processes underway in the network. In this case the issue to examine is whether at low "p" values (i.e. large average distances) the system behaves in the same way as in the case of connected Erdős-Rényi networks.

6.1. THE EFFECT OF THE STRUCTURE OF THE SOCIAL NETWORK OF EMPLOYEES

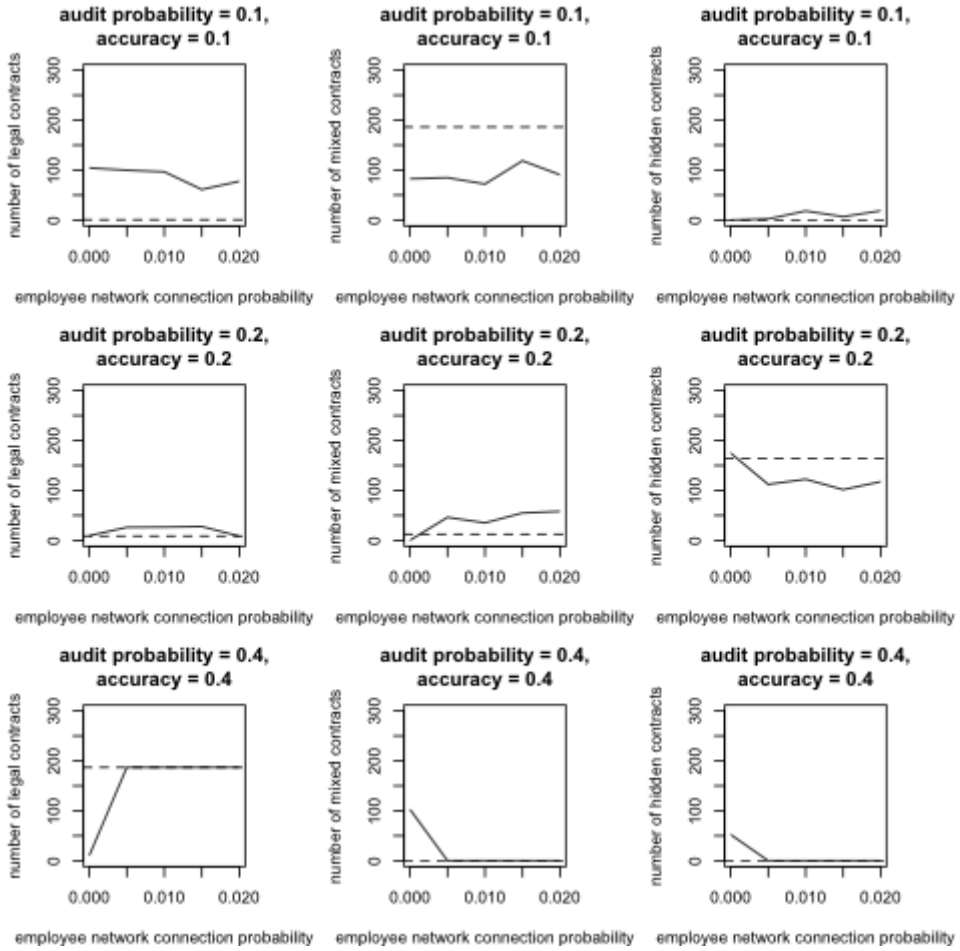
In Figures 6.1.1. and 6.1.2. we vary the structure of the employees' social network. On the former Figure the network belongs to the Erdős-Rényi family. In the latter figure, on the other hand, networks were generated using the Watts-Strogatz model.

The Figures show nine panels. The probability and precision of tax audit are equally 0,1 in row one, 0,2 in row 2, and 0,4 in row three. The figures show the number of legal contracts in the column on the left hand side, mixed employment in the central column and the size of hidden economy in the right hand side column. In the figures the horizontal axis shows the value of the "p" probability parameter of the particular network model (i.e. the probability of edges in the case of the Erdős-Rényi network and the probability of „shortcuts” in the case of the Watts-Strogatz network), while the vertical axis shows the amount of the particular employment.

In Figure 6.1.1. we analyse the effect of the parameter regulating the probability of the connectedness of employees' social network in the ranges between 0.0 and 0.02. This range includes the critical region between 1/N-3/N discussed earlier, when the network generated becomes connected. As Erdős-Rényi random networks are essentially stochastic, a single network generated always contains certain elements of eventuality. Therefore, we have drawn the averages of the results of 10 runs in the figure for each parameter combination. The dotted lines shown in the figure indicate the result of the measures we conducted in the course of the tax audit tests of Section 2.1. (Those runs were conducted with 0.1 network density).

Figure 6.1.1

Effect on the number of hidden, mixed and legal contracts in the Erdős-Rényi random network of the change in the parameter indicating the connectedness of employees' social network.

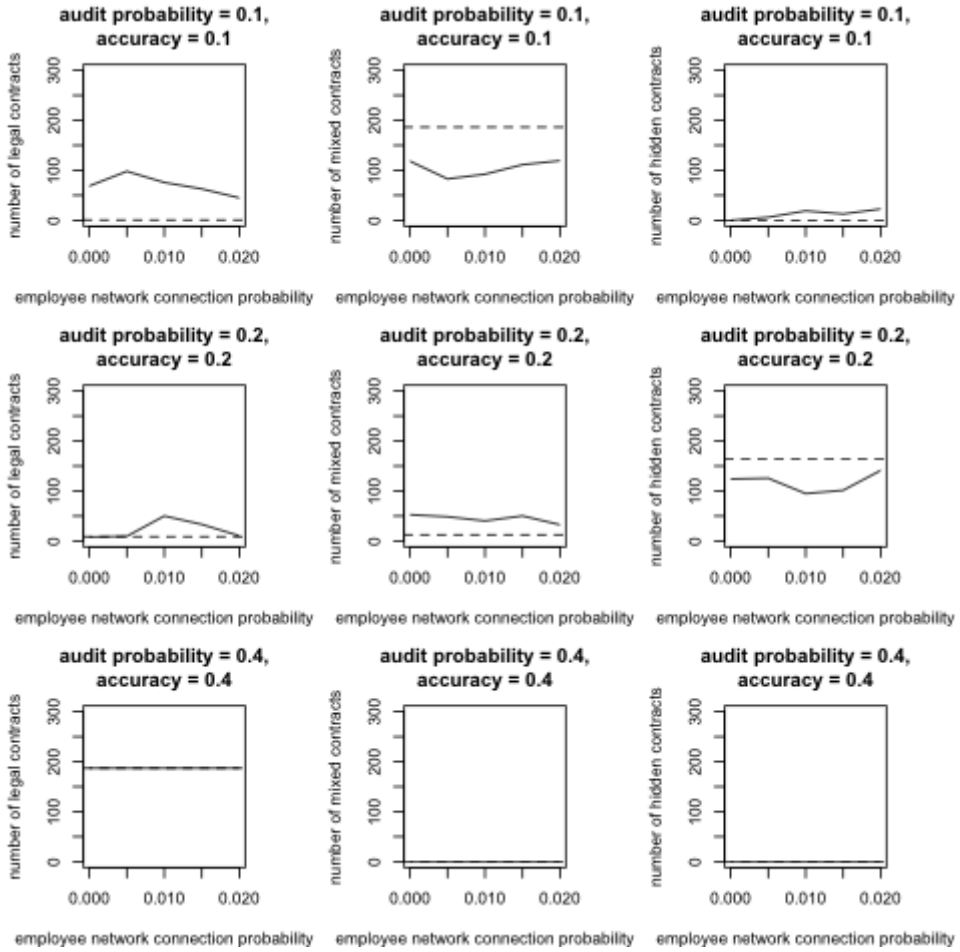


The main lesson that can be drawn from the Figure is that the role of the network on the result of the model primarily appears with high tax audit probability and precision. (This also coincides with the results of our factor analyses). This effect becomes manifested the most in the lowest row, where it is apparent that legal contracts become dominant with the emergence of connectedness. The results of the connected network regime also coincide with the results measured at high connectivity (indicated with a dotted line) and thus can be considered as monotonous. One interpretation of this observation is that information learnt through the network becomes important when it actually has an affect of changing behavior (i.e., when the perceived high audit probability prompts the agents to legalize their contracts).

We analysed in Figure 6.1.2. the effect of the parameter regulating the probability of „shortcuts" int he employees' social network, in the range between 0.0 and 0.02 range, in the case of Watts-Strogatz networks. As we did it in the previous case, here again we took the averages of the results of 10 runs for each parameter combination. Here again the dotted lines seen in the figures indicate the results of the tests performed in Section 2.1.

Figure 6.1.2

The effect on the number of hidden, mixed and legal contracts on the Watts-Strogatz network of the parameter indicating the probability of connectedness of the employee social network when the parameter for neighbours is 2



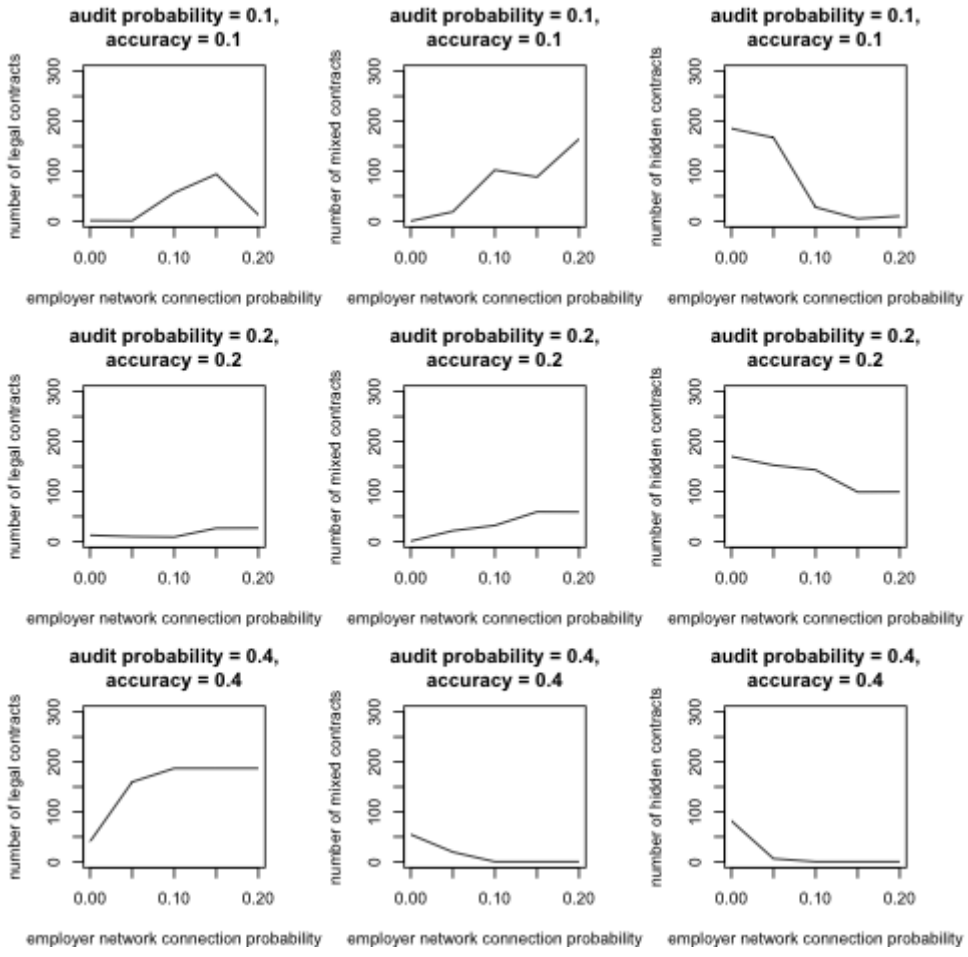
The main lesson one can draw from the Figure is that in the case of Watts-Strogatz networks the probability of "shortcuts" does not have any significant impact on the outcome of the TAXSIM model. In general terms it means that if employee networks are connected, the specific structure of this network does not influence the behaviour of the system. This is akin to many findings related to spreading processes, where the control parameter was often found to be the average distance in the network.

In Figures 6.2.1. and 6.2.2. we vary the social network of employers. In the analyses of the former figure the network belongs to the Erdős-Rényi family. For the latter figure, we generated networks using the Watts-Strogatz model.

Here again nine panels can be found in the figures. The probability and precision of tax audit are equally 0.1 in Figure 1, 0.2 in Figure 2 and 0.4 in Figure 3. The figures show the number of legal contracts in the left-hand side column, that of mixed employment in the column in the middle and the size of hidden economy in the right hand side column. Each figure shows the value of the „p" probability parameter of the network model concerned on the horizontal axis (i.e. the probability of the edges for the Erdős-Rényi network and that of the "shortcuts" for the Watts-Strogatz network) and the number indicating the size of the particular type of employment on the vertical axis.

Figure 6.2.1

Effect of the connectedness probability parameter of the employers' social network on the number of hidden, mixed and legal contracts on the Erdős-Rényi random network

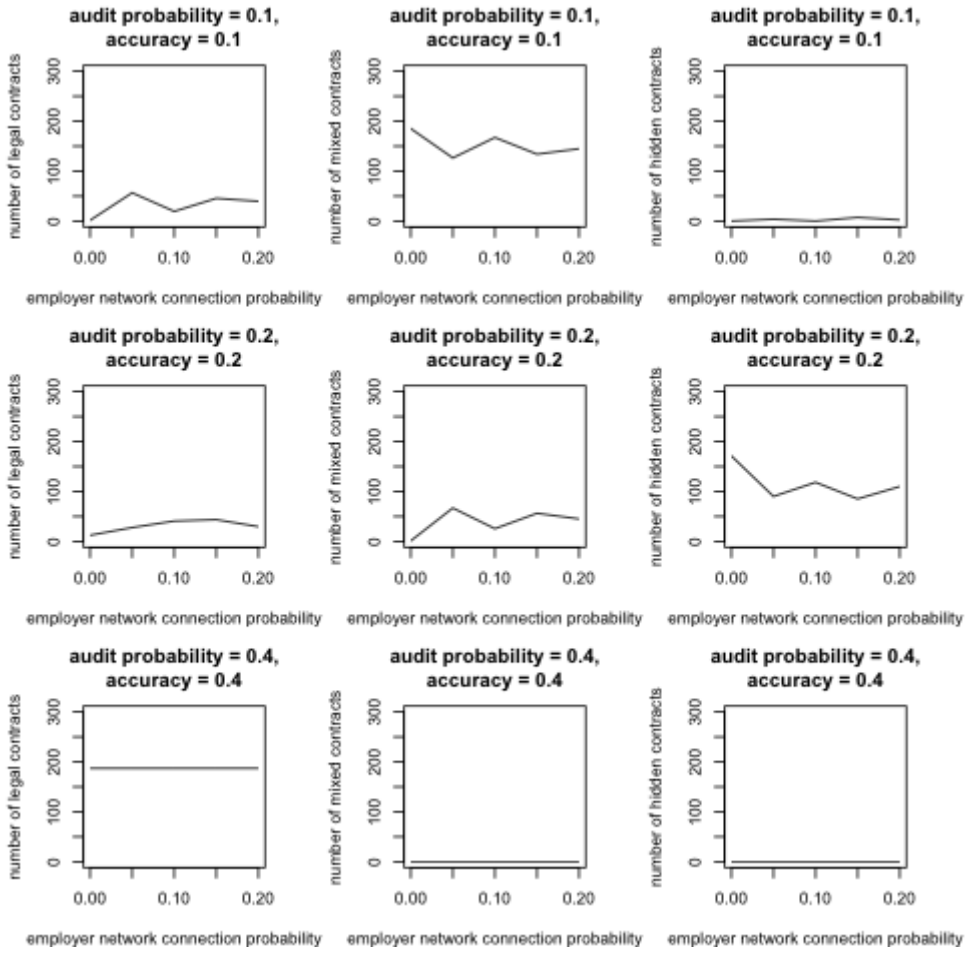


In Figure 6.2.1. we examine the effect of the parameter regulating the probability of the connectedness of the employers' social network in the 0.0 and 0.2 range. In the case of this network this range includes the critical path between 1/N-3/N discussed earlier, when the network generated becomes connected. (We took the average of the results of 10 runs for each parameter combination.)

Here again the role of the network in the outcome of the model appears primarily when the probability of tax audit and precision is high. (It also coincides with the results of our factor analyses). This effect becomes manifest the most in the lowest row (although it is already obvious in the middle row). It is clearly visible that legal contracts dominate as connectedness emerges. (See our interpretation above.)

Figure 6.2.2

The effect of the probability of „shortcuts" in the employers' social network on the number of hidden, mixed and legal contracts on the Watts-Strogatz network, when the parameter for the number of neighbours is 2.



In Figure 6.2.2. we examine the effect of the probability of „shortcuts” in the employers' social network in the 0.0 and 0.2 range, in the case of Watts-Strogatz networks. As earlier, here again we took the average of the results of 10 runs for each parameter combination.

The main lesson is that in case of Watts-Strogatz networks the probability of "shortcuts" does not have a significant effect on the outcome of the TAXSIM model. Here again the general observation is that as long as the employers' network is connected, the behaviour of the system is unaffected by the specific structure of the network.

7. THE UNEMPLOYMENT EXPERIENCE

Earlier analyses into tax payer’s behaviour failed to attach significance to the effect of business cycles on tax evasion. One of the manifestations of the effect of business cycles can be the rate of unemployment among tax payers. More recent empirical research indicates a significant and positive relationship between the size of unemployment and the willingness to pay tax: a higher rate of unemployment is accompanied by an increased prevalence of tax evasion (Alm-Yunus, 2009 and Cebula-Feige, 2011).

In our opinion the analysis of the tax payer's perception and expectations is especially important from this viewpoint as well: to what extent does the tax payer feel themselves threatened by unemployment and, consequently, how does their willingness to accept less than legal contracts changes?

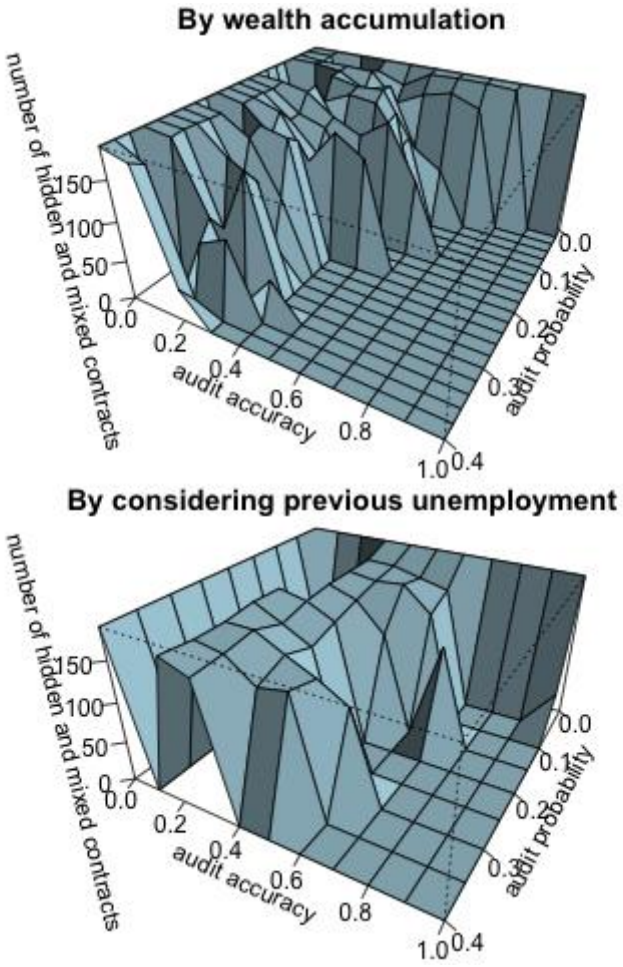
In the TAXSIM model the unemployment experience influences employees' behaviour in two ways. In the basic model job hunters continue to stick to their own tax payment concept (another driver of which is the quality of governmental services) as long as their financial possibilities make it possible. However, as soon as they run out of their accumulated money, they become more open to the employers' less than legal offers.

In the extended model employees remember their previous unemployment experience and the accompanying discomforts. So, in case of a repeated job search (i.e. unemployment) the employee will immediately seize every possibility and take an open attitude to even less than legal employer offers.

In this Section we compare the ways these two models of unemployment experience effect the model’s outcome. The figure below shows the probability and precision of tax audit on the horizontal axis, whereas the vertical axis shows how the number of non-registered contracts works out.

Figure 7.1

Effect of the unemployment experience on non-registered employment



As testifed by Figure 7.1. taking the unemployment experience explicitly into consideration clearly increases the probability of the appearance of black and gray economy. It is worth noting that in this case the precision/efficiency of tax audit will have a much more significant effect on the outcome than the mere probability of it.

It is also remarkable that the effect of accuracy is not linear in the lower region. If audit is totally inaccurate (0.0 probability), the economy will understandably be black. With low, but positive precision, on the other hand, we get into the non-legal regime, which is then followed by the dominance of registered employment as audit accuracy increases.

Conclusions

The main objective of our research has been the analysis of the relationship of the government and tax payers, more specifically the exploration of the impact such relations have on paying taxes. We have used the TAXSIM agent-based simulation model for our analyses and this study reports our detailed results.

First we discussed the general behaviour of the model in various parameter ranges. When we analysed the factors embracing the first and broadest range we came to the conclusion (coinciding with previous experiences) that the model's behaviour is influenced to the greatest extent by the probability of tax audit and its precision (two model parameters). Then we systematically applied the model to various combinations of these parameters and found that the model's behaviour falls into two well separated regimes. If the probability and the precision of tax audits are low, the great majority of the contracts are non-registered (either mixed or hidden ones), while a higher probability and precision of tax audits result in more legal contracts.

The same general pattern emerges both in case of mild labour market competition and full employment and strong labour market competition and lack of employment. However, in an environment where almost every employee has a job, employees are less likely motivated to evade taxes and hidden contracts appear practically only when there is no tax audit at all. Contrary to this, in a more competitive labour market, the two different outcome regimes appear different: it takes a much higher audit probability to make the transition happen and to lead to a legal economy. When analysing the two market scenarios separately, we found that the parameters influencing the traits of social (employer and employee) networks as well as the parameters influencing the services extended by the government are also important in determining the level of tax avoidance, in addition to the efficiency of tax audits.

The first step in the analysis of the specificrelationship between the government and tax payers was the review of the case when tax audit efficiency grows. We examined two audit strategies and, specifically, the mixed strategies deriving from them: a random and an adaptive strategy of audit. In the first case the tax authority randomly selects employers as audit targets, while in the second, they audit the acquaintances of employers having been caught in tax evasion earlier. According to our results, legal employment grows considerably and hidden employment declines as the tax authority selects adaptively to an increasing extent among employers. The adaptive conduct of the tax authority is an efficient tool in the campaign against tax evasion.

Another area of the relationship between the government and tax payers is the quality of the services offered by the government. Analysing this issue we examined an economy with a

strong oversupply in the labour market and found that services extended to employers dominate. In the range of the parameters where the quality of the services offered to employers is poor, a considerable amount of hidden employment can be detected, whereas when the quality of such services is good, legal employment is considerable and mixed contracts dominate with the interim values of service parameters.

We also examined the effect of an eventually implemented and, respectively, increased minimum wage. We took the minimum wage into consideration in the model as a minimum amount of tax payable. According to our results the minimum wage slightly legalizes economy in the particular parameter range of the TAXSIM model. The size of non-registered employment tends to decline already with a lower level of tax audit precision and less frequent auditing and, along with it, the steepness of the transition from non-registered to legal also increases. At the same time it can be concluded that the implementation of the minimum wage reduces the ratio of mixed employees against hidden employees in the economy that is otherwise becoming legalized. That is, those who are unable to adapt (turn legal) will be more often compelled to withdraw into the hidden economy instead of mixed employment. At the same time our results suggest that this effect reverses when the size of the minimum wage grows. When this happens, a slight change can be observed among non-registered forms of employments moving from hidden economy towards mixed employment.

In addition to the relationship between the government and the tax players we also examined the effect of the employers' and employees' social network structure. With regards to social networks we examined two different network structures, the Erdős-Rényi-type random network and the Watts-Strogatz-type network. The main lesson deriving from the results is that the effect of the network structure on the result of the model is pronounced at high levels of tax audit probability and precision. (This coincides with the results of our factor analyses). This effect manifests itself mostly in the region when network becomes connected, leading to a situation where legal contracts tend to dominate. With the Watts-Strogatz networks the likelihood of „short cuts" does not have a significant effect on the outcome of the TAXSIM model. In general, it means that as long as the employee network is connected, the specific structure of the network will not influence the behaviour of the system.

Finally, we examined the effect of the experience of unemployment on legal employment. We used two models of this experience: in the first employees accumulated assets as they worked and they lived on such assets when they were unemployed. In this model employees accept an un-registered contract only in the event they run out of their accumulated wealth. In the other version, in the event of repeated unemployment, employees are immediately prepared to accept a less than legal contract. According to our results the explicit consideration of the unemployment experience clearly increases the probability of black and grey economies.

To summarize, our analyses conducted using the TAXSIM model suggest that governments can choose among several efficient tools to improve tax compliance and curb tax evasion. In addition to improving the frequency and precision of tax audits, the implementation of an adaptive strategy of tax audit may also be effective, as well as reducing the threat of unemployment among employees (i.e., reducing the rate of unemployment), or improving the quality of government services.

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